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THE RESEMBLANCE OF SIBLINGS IN INTELLIGENCE AND ACHIEVEMENT

BY

GERTRUDE HOWELL HILDRETH

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

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G. H. H.

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THE RESEMBLANCE OF SIBLINGS IN INTELLIGENCE AND ACHIEVEMENT

CHAPTER I

THE PROBLEM

INQUIRIES into the subject of mental heredity have been numerous since the initial studies made by Sir Francis Galton more than a half century ago. Since that time there has been a progressive refinement in methods of gauging intelligence and in treating data by statistical method. Consequently, more reliable results may now be expected from such studies than were possible when studies of the subject were first undertaken.

POSSIBLE METHODS OF STUDYING THE PROBLEM

There are several possible methods of attack upon the general problem. One method would be to obtain measures of the intellectual capacity of members of the same family for several successive generations and to determine the resemblances between the members of the different generations. Any resemblance that could not be accounted for by similarity in environment would be attributed to the factor of heredity. This method is, of course, inapplicable at present because of the lack of measures of successive generations.

A second method is that of limiting the investigation to a study of individuals of one generation only. This method is highly feasible and quite satisfactory for a study of certain aspects of the general problem. This second method has been adopted in this research.

It is evident that, for such a study, the most precise methods of measuring intelligence are desirable. Before the introduction and standardization of intelligence tests, accurate methods for determining the amount of intelligence an individual possessed were lacking. Rough estimates and those of an almost wholly subjective nature were the only means of gauging mentality. The

standardized intelligence test, though by no means as yet a perfect instrument, enables the research worker to obtain more objective and accurate measures of intelligence than would otherwise be possible. Standardized intelligence tests have therefore been used throughout this study.

PHASES OF THE PROBLEM TO BE INVESTIGATED

The specific points to be investigated in this study are the three following:

1. To determine whether or not there is positive resemblance in the mental capacity of pairs of siblings (children of the same parents) which is greater than might be expected from pairing unrelated children by chance.
2. To determine as precisely as possible the amount of the resemblance of siblings in intelligence.
3. To discover whether or not the factor of heredity or that of environment is the more potent in causing this resemblance.

The relation which the specific points enumerated bear to the general problem is intimate. If similar amounts of mental ability tend to recur in siblings and do not tend to recur in unrelated children paired at random, and if the effect of similar environment in the case of siblings can be eliminated, evidently the factor of heredity is responsible for existing similarities, and the similarity is attributable to the same ancestral germ plasm.

INTELLIGENCE TESTS AS MEASURES OF INNATE MENTAL CAPACITY

Since intelligence tests are to be used as measurements of mental ability in this research, it is well to note the objection which many students have raised to their use as gauges of innate or native ability. The contention is that the tests measure ability through the medium of environment and not independently of it. This is quite true. No one pretends to measure intellectual capacity before the force of environment has played upon the individual. The answer to the argument is simply that the various elements which compose an intelligence test are standard situations in the environment to which a child cannot react successfully until the mental capacity to do so has developed. The whole argument is admirably set forth by Kuhlman,[1] who says,

[1] Kuhlmann, F., *A Handbook of Mental Tests*, pp. 29-30.

"Taken literally, all tests are and must be dependent upon training. There is no mental development without mental content, and no motor ability without motor training. Also, for the child to understand the examiner when he tells him what to do in a test, and to respond in words or acts requires mental and motor activities that have been acquired by training. Instead of being independent of training in this sense, all tests can aim simply to determine the effects of training and no more. But according to the capacities of different children, these effects are much or little, and thus the tests come to measure these capacities, capacity here being simply another term for intelligence. The requirement, therefore, cannot be independence of training, but only independence of a widely variable training." He calls attention further to the fact that the only kind of tests that can be said to be strictly independent of training in a special sense are tests or tasks "of such a nature that attempts to learn to do them, practice, does not materially affect the ability to do them." Most tests, however, are susceptible to training; the ability of subjects to learn to do the tasks involved when similar opportunity is provided, is the desired measure of native mental capacity.

Colvin [2] says, "The truth of the matter is that when an environment is practically the same for a group of individuals, then the great differences that are found among these individuals are due to differences in native capacity."

The separate tests in the Stanford Binet Scale may be considered as common, in general, to the experience of school children of the United States of appropriate age. In the light of this explanation, then, the terms "intelligence test, mental measure, test of mental capacity," and the like, will all imply indirect tests of innate intelligence.

THE CONCEPT OF INDIVIDUAL DIFFERENCES

To a complete understanding of the general problem, the concept of individual differences is immanent. In both the organic and inorganic realms, the fact of individual variation among members of a class is a constant phenomenon.

Resemblance of members of a species to a common type with varying degrees of difference among the individual members, is a demonstrable fact in organic structures. The complex mind of

[2] Colvin, S. S., "Construction and Use of Intelligence Tests." *Twenty-first Yearbook, National Society for the Study of Education*, p. 19.

man cannot escape the rule. In mental ability as in organic structure, differences are found between individuals of the same class or fraternity. The average schoolroom where no attempt at scientific classification has been made, will illustrate the fact that large differences will be found between the mental capacities of the most and least gifted. The majority of the group tends to cluster about a point of mediocrity. A sufficiently large random sampling of an unselected population will yield a distribution approximating a curve of normal distribution for physical and mental traits.

Sir Francis Galton was one of the earliest to recognize the operation of this principle in human biology and to make use of it in studies of heredity. Galton [3] noted two opposing tendencies in individuals: the one, to deviate from the average or central tendency of the race; the other, to regress toward the central tendency of the race, the combination of the two tendencies resulting in a compromise. These two tendencies help to explain the appearance of both resemblances and differences in related individuals.

PRACTICAL SIGNIFICANCE OF THE PROBLEM

The problem is of practical significance; in fact, the present study developed from a practical situation. It was the writer's experience, while administering intelligence tests in a city school system, to encounter large differences as well as close resemblances between related individuals. The question at once arose as to the amount of the resemblance present on the average, between related individuals in the population, and concerning the cause of the resemblance or differences found. It was questioned whether resemblances were greater among related than among unrelated people; whether they were as great among unrelated children reared together as among related children; among unrelated children in the population at large as among related children reared apart. If there are real and not illusory differences and resemblances, what causes them? Are they increased or decreased by appropriate environmental conditions? How do the results of scientific studies of the problem compare with popular opinion on the subject as reflected in folklore, art, drama, and fiction? Answers to these questions have an important bearing

[3] Galton, F., *Natural Inheritance.*

upon problems of genetics, education, eugenics, sociology and related sciences. Consequently, scientific studies of any aspects of the problem are of value.

SIBLINGS IN LITERATURE

Public opinion as reflected in folklore, art, drama, and fiction has been inclined to emphasize differences rather than similarities of ability in siblings, probably because of the fact that the former are more evident and problematical. Results may show also that they are more unusual and consequently receive undue attention. A few citations will illustrate the point.

Kate, the shrew, remarks Boas, the Shakespearian commentator, is greatly superior to her sister Bianca, "in qualities both of head and heart." The extreme differences between the two are apparent throughout the play. The drama *Lear* depicts three sisters, the youngest of whom differs markedly from the elder two. In this respect it resembles the common folk and fairy tale in which the elder two of three sibs are portrayed as cruel, ignoble, inferior; the youngest as good, beautiful, and in general superior. The Norwegian legend, *Peter, Paul and Espen,* relates the adventures of three brothers, the youngest of whom surmounts all obstacles to success, and wins the king's favor after the ignominious failures of the two elder brothers.

The Bible furnishes similar interesting examples. David, the youngest, overcomes the giant with bravery and intelligence,—qualities clearly lacking in the three elder brothers. Jacob and Esau were twins, yet markedly dissimilar in physical and mental traits. Esau is pictured as the "cunning hunter," Jacob as "a plain man and dweller in tents." The differences may be accentuated by the fact that the siblings are referred to a twofold classification of ability rather than to a multifold scheme. An individual is good or bad, capable or incapable, bright or dull. No place in the classification scheme is allowed for average ability. The old comic song, "Bohunkus," illustrates the point. Through four verses, the extreme differences between the two boys in all their activities are depicted. Even the manner of death and the final destinations of the brothers can best be described as antipodal. In *Uncle Tom's Cabin* are described two brothers who appear to be dissimilar in every trait, and these differences

are transmitted to their respective children. Is this an extreme picture, more unusual than usual?

The examples in literature of similar sibs seem far less numerous. Even when similar sibs are depicted, attention is seldom called to the fact that they are similar. (A plot rarely centers about similarities in siblings as it frequently does about differences.) An exception is found in *Twelfth Night.* Viola and Sebastian, though of opposite sex, are so similar in physical appearance as to cause confusion, and there is evidence that they are similar in mental traits as well. The family in the *Vicar of Wakefield* shows greater resemblances than differences. Naïvete and gullibility appear in all the members, with distressing consequences. The children of Bob Cratchit appear more similar than different in most traits. In the story of *Penrod,* the colored brethern, Herman, Sherman, and Verman, would seem to be carbon copies were it not for Verman's speech defect. In *Les Miserables* the similarity of the Thenardier children, whether due to heredity or environment, cannot be overlooked. They stand out in contrast to Cosette to whom they are, of course, unrelated. Ben Hur and his sister retained the noble qualities they had in common in spite of long separation and devastating environmental circumstances. Other examples can be given, but they are monotonous and uninteresting, a fact which accounts for their apparent infrequency and obscurity.

PLAN FOR THE STUDY OF THE PROBLEM

The investigation of the three points previously mentioned (1) whether or not resemblance is greater or less between related than between unrelated individuals; (2) the determination of the amount of the resemblance; (3) a study of the relative influences of environment and heredity in causing resemblances and differences which may be found, necessitated certain methods of attack which will now be described.

Investigation of (1) and (2). For a study of these two points, it was decided: (*a*) To obtain a large number of pairs of siblings as free from selection as possible in order to get at least an approximation to a normal distribution of talent; (*b*) to obtain measurements of the intelligence of these children; (*c*) to pair unrelated children at random, and compare the amount of their resemblance with that for related children; (*d*) to use ap-

appropriate statistical methods for calculating amounts of resemblance.

Investigation of (3). For a study of this problem, a statement made by Terman [4] was suggestive. He says, "It will be better evidence . . . (of the relative influences of heredity and environment) . . . if someone can show that foster sibs (of unknown parentage) adopted early, resemble each other or their foster parents as much as true sibs resemble each other or their true parents; or if it can be shown that by special treatment from an early age, the I.Q.'s of a group of 50 or 100 children can be raised significantly above the I.Q.'s of their untreated sibs. The issue here is one of the most important that humanity faces and one that will some day be decided on the evidence of mental tests."

For a time, the writer contemplated carrying out the study with measurements of foster children adopted at an early age into families having one or more children. This project was abandoned, however, when a somewhat different method was decided upon. An orphan asylum was found in which all of the wards were given mental examinations as a part of their record. Unrelated orphans reared together furnish data somewhat comparable to that which might be obtained from foster sibs reared in families with other children. It was decided to use orphan asylum data because of the opportunity of gathering a greater amount of data than would otherwise be possible. It was believed possible to estimate four kinds of relationship in the orphan group which would have a bearing upon the problem:

a. Resemblances of true sib orphans reared together.
b. Relation of unrelated orphans reared together for a longer or a shorter period of time.
c. Relation of unrelated orphans reared apart.
d. Resemblances of related orphans reared apart from a certain age, but eventually brought together at the asylum and tested.

A number of objections could be brought against the use of the foregoing plan in attempting to separate the influences of heredity and environment, and to estimate their relative weight in causing likenesses and differences in related individuals. The first of

[4] Terman, L. M., "The Mental Test as a Psychological Method," *Psych. Rev.*, Vol. 31, No. 2, p. 117 (March, 1924).

these is that unless the environments in which true sibs are reared apart are radically different, the method is ineffective. Again, environmental effects of early years are believed to be more potent than those of later years. Hence the method is invalidated if all the foster sibs have not been reared together from earliest years and for equal numbers of years. These difficulties have not been entirely surmounted in the course of the investigation. The ideal has not been attained, and the results must be interpreted in the light of any shortcomings in the method.

An attempt to gain further insight into problem (3) was made by the use of measurements of educational attainment of true siblings. The question is whether true sibs resemble each other more or less in abilities greatly subject to environmental influence than they resemble each other in innate intellectual ability. Thorndike calls attention to the fact that "If training is the cause (of resemblance in twins) twins should show greater resemblance in the case of traits much subject to training, such as, ability in addition or in multiplication, than in traits less subject to training, such as, quickness in marking off the A's on a sheet of printed capitals, or in writing the opposites of words.

"On the other hand . . . the nearer twin resemblance in relatively untrained capacities comes to equaling that in capacities at which the home and school direct their attention, the more must the resemblance found be attributed to inborn traits." [5]

The same general argument has been applied to the sibling data of this study in regard to tests of school subject achievement as contrasted with tests of innate intelligence.

A number of valuable contributions to the general problem have already been made and will be summarized briefly in the following chapter.

[5] Thorndike, E. L., *Measurements of Twins*, p. 2.

CHAPTER II

SUMMARY OF PREVIOUS STUDIES OF VARIOUS PHASES OF THE PROBLEM

MANY contributions have been made to various phases of the general problem. A number of different methods have been employed and varying conclusions have been reached.

CLASSIFICATION OF THE VARIOUS STUDIES

In summarizing the most important of these studies, no attempt will be made to classify them according to method, importance, or excellence. A rough chronological order will be followed. Although the studies themselves will not be classified, and probably could not be classified on any one basis, it is well to call attention to several possible bases of classification.

1. On the basis of the number of generations involved in the investigation:
   - *a*. Studies of the family history type, involving at least two generations, and usually many generations of individuals in a family.
   - *b*. Studies involving the individuals of only one generation, of which the present study is an example.
2. On the basis of scientific measurement or lack of it:
   - *a*. Studies which estimate intelligence on a subjective, qualitative judgment basis, and refer the individuals to categories of ability.
   - *b*. Studies in which scientific mental measurement has been made of the individuals studied, the measurement being objective in character, and the results of a quantitative sort.

The older method is (*a*), and it was the only one possible before the introduction of tests and measurements; (*b*) is of comparatively recent development, and constitutes a sharp line of demarcation between the older and more recent studies. It is the most important single change in method that has occurred throughout the course of the several investigations.

3. On the basis of the presence or absence of statistical method in summarizing the data:

a. Studies in which no use is made of statistical methods in tabulating and summarizing the data. At first thought, the family history method and rigid statistical treatment seem incompatible. Whether or not this is true depends upon the nature and treatment of the original data. In the hands of an expert, such as Galton, with no better data than categorical ratings of raw qualitative judgments of ability, some of the most important and far-reaching principles of heredity and of statistics were worked out.

b. Studies in which the data are summarized by statistical treatment. Quantitative measurements, such as those found throughout the physical sciences, are much more readily and satisfactorily treated by statistical methods than are qualitative judgments and coarse classifications. Increased use of statistical method has consequently gone hand in hand with refinement in gauging intelligence.

Most of the studies to be reported here do not belong solely to any one of the classifications given above. They may be characterized by a mixture of method and treatment of results. Statistical method may be used in part, but not throughout the study. There may be evidence of much measurement but little statistical treatment. The investigations may report a study of a single family or of hundreds of families, with resulting differences in data and conclusions. Several studies investigate the inheritance of both physical and mental traits, and draw attention to the analogy between the two. Results for both the physical and mental traits will be summarized here, but no account will be taken of investigations solely devoted to the inheritance of physical traits. Studies of the resemblances of siblings in both intelligence and school subject achievement will be summarized.

THE WORK OF GALTON

Galton,[1] who may be said to have inaugurated the eugenics movement, endeavored to find out whether or not genius or

[1] Galton, F., *Hereditary Genius.*

natural ability was hereditary and in what degree natural ability was transmitted. He compiled lists of the most eminent men (*eminent* meaning the most gifted man in 4,000) of many professions,—judges, statesmen, commanders, literary men, men of science, poets, musicians and painters, protestant divines, senior classics of Cambridge, oarsmen and wrestlers. Having obtained a large enough number for statistical treatment, his method of proving genius hereditary was to determine the frequency with which illustrious men had illustrious relatives. He found that of 286 judges, more than one in every nine had been either father, son or brother to another judge. He found that there was one chance in four that the son of an eminent son of a judge would become eminent, whereas there was only one chance in thirty that the son of a non-eminent son of a judge would become eminent. In order to answer the argument that environment and not heredity was responsible for the appearance or non-appearance of genius, he contrasted the nephews and more distant relatives (adopted sons) of popes with real sons of eminent men, and found that the ability of the adopted sons was by no means equal to that of the real sons of eminent men.

By investigating cases of similar twins reared apart and dissimilar twins raised together, Galton [2] studied further into the question of the respective shares of nature and nurture in influencing character and intellect. Reasoning from the fact that similar twins remain similar in spite of different environment, and that dissimilar twins retain their dissimilarity though reared in the same environment, Galton concluded heredity to be more influential than environment in shaping the disposition and intellect of men.

A further contribution to the general problem was made by Galton [3] in a study of family resemblances in physical and mental traits of over a thousand individuals from 150 families. He devised and employed a graphic method for determining relationship, obtaining results as follows:

Regression coefficients in height and eye-color

(1) between brothers 2/3
(2) between parent and child 1/3

[2] Galton, F., *Inquiries Into Human Faculty and Its Development.*
[3] Galton, F., *Natural Inheritance.*

He calculated resemblances for temper and the artistic faculty also, and concluded that the same laws of relationship operated in these traits as in the physical. The great contribution of this study proved to be the concept of fraternal and filial regression.

FURTHER STUDIES OF THE PROBLEM

Classical studies of the family-history type, investigating all available data concerning a single family for successive generations, were made by Dugdale[4] and Goddard.[5] Both studies showed by contrasting products of good and bad family strains that the mentally and morally gifted stocks produced a much larger proportion of mentally and morally able offspring than did the inferior stocks. The product of the latter was found to be predominantly inferior.

Woods[6] investigated hereditary mental and moral trends in the royal families of Europe in order to determine the part played by heredity in the formation of mental and moral qualities. He obtained mental and moral descriptions of over 600 interrelated individuals of countries of Europe from the sixteenth century. These he graded on a scale of one to ten for mental and moral qualities. He then computed correlations for different degrees of relationship, including parent and child, grandparent and child, and great-grandparent and child. For intelligence the results were:

Parent and child, 504 pairs	$r = .3007 \pm .0472$
Grandparent and child, 952 pairs	$r = .1506 \pm .0369$
Great-grandparent and child, 179 pairs	$r = .1528 \pm .0332$

For moral qualities the results were:

Offspring and parents	$r = .2983$
Offspring and grandparents	$r = .175$

Woods concluded heredity to be a cause of mental and moral peculiarities; and further concluded, on the basis of comparisons of closer and more distant relationships, that environment was not so strong a force in the formation of mental and moral traits.

Pearson[7] made inquiries into the laws of inheritance in man

[4] Dugdale, R. L., *The Jukes.* Thirty-third Annual Report of the Prison Association of N. Y., 1876.

[5] Goddard, H. H., *The Kallikak Family.*

[6] Woods, F. A., *Mental and Moral Heredity in Royalty.*

[7] Pearson, K., "On the Laws of Inheritance in Man." *Biometrika,* Vol. III, pp. 131-90. Also Pearson. K., "On the Relationship of Intelligence to Size and Shape of Head and to Other Physical and Mental Characters." *Biometrika,* Vol. V, pp. 105-46.

for mental, moral, and physical traits. The results of Pearson's work in regard to physical traits for a thousand families, follow:

INHERITANCE OF PHYSICAL CHARACTERISTICS—ADULTS

Character	Correlation		
	Brothers	Sisters	Brothers and Sisters
Stature	.51	.54	.55
Span	.55	.56	.53
Cubit	.49	.51	.44
Eye Color	.52	.45	.46
Mean	.52	.51	.49

SCHOOL CHILDREN

Character	Correlation		
	Brothers	Sisters	Brothers and Sisters
Health	.52	.51	.57
Eye Color	.54	.52	.53
Hair Color	.62	.57	.55
Cephalic Index	.49	.54	.43
Head Length	.50	.43	.46
Head Breadth	.59	.62	.54
Head Height	.55	.52	.49
Mean	.54	.53	.51
Athletic Power	.72	.75	.49

Pearson carried on his study in regard to mental traits by using a sixfold division of intelligence: dull, slow dull, slow, slow intelligent, intelligent, quick intelligence, by which the different individuals were classified. He obtained for pairs of sisters, a correlation of .47. For investigating certain psychical characteristics, he used a threefold category for estimating the amount of the trait possessed by the individual.

Since Pearson found similar amounts of resemblance for mental and physical traits, and since the latter he believed could be little influenced by environment, he concluded the same must be true of mental traits. The environment he believed to be but a part of the heredity of the stock. He concluded that both physical and psychical traits are inherited in much the same manner and

to much the same extent. The results which Pearson obtained for about 2000 pairs of sibs follow:

INHERITANCE OF MENTAL CHARACTERISTICS—CORRELATIONS

Character	Brothers	Sisters	Brother-Sister
Vivacity	.47	.43	.49
Assertiveness	.53	.44	.52
Introspection	.59	.47	.63
Popularity	.50	.57	.49
Conscientiousness	.59	.64	.63
Temper	.51	.49	.51
Ability	.46	.47	.44
Handwriting	.53	.56	.48
Mean	.52	.51	.52

Schuster and Elderton [8] computed correlations for scholarship between brothers and between fathers and sons of members of Oxford College and the schools of Harrow and Charterhouse. For filial resemblance, the result was .31; for fraternal, .40. The correlation for cousins was found to be .27.

Thorndike's [9] study of twins was the earliest to make use of objective measures of intelligence in studying mental heredity. Measurements of fifty pairs of twins were reported and the bearing of the results upon the relative importance of heredity and environment in causing resemblance was shown.

Correlations for the fifty pairs were obtained as follows:

Test	Twins	Siblings	Younger Twins	Older Twins
Cancellation of A's	.69	.32	.66	.73
Cancellation of *a*-T and *a*-*e*	.71	.29	.81	.62
Misspelled Words	.80	--	.76	.74
Addition	.75	--	.90	.54
Multiplication	.84	--	.91	.69
Opposites	.90	.30	.96	.88
Average	--	--	.83	.70

The conclusion was reached that heredity was the more potent factor in causing these resemblances.

Pintner [10] in a study of siblings used group tests for measuring

[8] Schuster, E., and Elderton, E., *Inheritance of Ability*, Eugenics Laboratory Memoirs, 1907.

[9] Thorndike, E. L., *Measurements of Twins.*

[10] Pintner, R., "Mental Indices of Siblings." *Psych. Review*, Vol. 25, No. 3, pp. 252-55.

mental ability, converting the scores into mental indices. The tests given were:

1. Rote memory for concrete words.
2. Digit-symbol test.
3. Symbol-digit test.
4. Word building.
5. Easy opposites.
6. Cancellation.

The study included 180 families of two children, and 37 families of three children. The question raised was whether or not there was greater similarity between siblings than between unrelated children. Both average deviations and association coefficients were computed. The results obtained were:

	Q	N
School A—sibs	.47	91
School B—sibs	.28	89
Both Schools—sibs	.39	180
Chance selection among sibs	.09	180
Another chance selection among sibs	.14	122
Chance selection of unrelated children	.14	151
Another chance selection of unrelated children	.19	300

The Pearson coefficient of correlation obtained for 180 pairs of siblings was .22 ± .021. Pintner concluded that siblings were more nearly alike in intelligence than non-siblings. This greater resemblance he believed was due to inheritance, since the tests were of such a nature as not to be greatly influenced by school training.

Starch [11] was interested in two phases of the problem. He attempted to determine (1) the extent to which siblings were alike in mental traits; (2) whether the similarity was greater in those tests directly affected by training in school work than in those traits which are not directly affected by school work.

For measuring ability in school work, tests of reading, speed, and comprehension, size of reading vocabulary, speed and quality of handwriting, ability in spelling, arithmetic fundamentals, and reasoning were used. The tests of mental functions used were perception tests, and tests of memory for words read. Motor capacity was tested by a tapping test.

[11] Starch, D., "The Similarity of Brothers and Sisters in Mental Traits." *Psych. Review*, 1917, Vol. 24, pp. 235-38.

Correlations computed by the Spearman rank method resulted in the following coefficients for siblings:

	Average Coefficient
Tests directly affected by school work.....	.42
Tests little affected by school work.....	.38

Starch concluded that since the resemblance was practically the same in those traits little affected by environment and in those traits much affected by environment, the resemblance found for siblings must be due to heredity.

Gordon [12] calculated resemblances for 91 pairs of orphan siblings, using intelligence quotients as measures of intelligence. If data were available for three children in a family, the youngest was omitted from the calculations. If I.Q.'s were available for four children in a family, two pairs were formed and entered into the correlation table. The two oldest were paired together and the two youngest together. The correlation computed by the Pearson formula was .53. Gordon believed this to be a fairly high degree of correspondence when compared with that of unrelated children which would be .00.

In a further study, Gordon [13] obtained for 216 pairs of orphans a correlation of .61. These data were later recomputed by Elderton [14] with the following results:

	Gordon's Pairing	All Pairs	All Pairs and Tables Symmetrical
I.Q. of Elder and I.Q. of Younger	.593 ± .030	.534 ± .024	.467 ± .026
I.Q. of Elder and I.Q. of Younger for Constant Age of Elder and Younger	.578 ± .030	.544 ± .024	.532 ± .024

In order to make a more thorough investigation of the problem, Elderton [15] obtained data for a small number of pairs of English school children. Intelligence tests were used as measures of mental ability and teachers' estimates of the intelligence of their

[12] Gordon, K., "Psychological Tests of Orphan Children." *Jr. of Delinquency*, Jan. 1919, Vol. 18, pp. 46-55.

[13] Gordon, K., *Influence of Heredity on Mental Ability.* Report of the Children's Department, State Board of Control of Calif., 1918-1920.

[14] Elderton, E., "A Summary of the Present Position with Regard to the Inheritance of Intelligence." *Biometrika*, 1923, Vol. 14, pp. 378-408.

[15] Elderton, E., *op. cit.*

pupils were obtained. The results of the study were as follows:

Sibs Uncorrected for Age	School A		School B	
	I. Q.	Teachers' Estimate	I. Q.	Teachers' Estimate
Brother–Brother	.669 ± .053	.768 ± .040	.394 ± .05[illegible]	.351 ± .057
Sister–Sister	.272 ± .060	.450 ± .05[illegible]	.461 ± .06[illegible]	.460 ± .065
Brother–Sister	.326 ± .044	.543 ± .036	.449 ± .036	.466 ± .033

The writer concluded that the limits set to ability were due to heredity rather than to environment; that the limits of a person's ability were to be attributed to his parents or ancestors rather than to the educational system in which he was reared.

For 63 pairs of siblings, Madsen [16] obtained a correlation of .63 ± .05 based on intelligence quotients. He concluded the correlation to be significant, since that for unrelated school children chosen at random would have been zero. He obtained a correlation of − .04 for 63 children in one school with 63 in another, and concluded that "intelligence runs in families."

Hart [17] obtained data for test results of three groups of school children. The tests used were Army Alpha, National, and Stanford Binet. Intelligence quotients were computed, and the following results were obtained:

	No. of Pairs	Pearson *r*
Davenport	252	.447 ± .034
Iowa County	147	.459 ± .066
University of Iowa Schools	219	.399 ± .057

He called attention to the tendency of intelligence to run in families, but also noted that wide divergences in ability in children of the same family were to be expected.

[16] Madsen, I. N., "Some Results with the Stanford Revision of the Binet Simon Tests." *Sch. and Soc.*, May 10, 1924, p. 559.

[17] Hart, H., "Correlations Between Intelligence Quotients of Siblings." *Sch. and Soc.*, Vol. 20, No. 508, Sept. 20, 1924.

From an unpublished study by Reusch reported by Merriam,[18] the following correlations were taken:

	Siblings No. of Pairs	*r* I. Q.'s
Palo Alto	104	.48 ± .046
San Jose Normal	61	.57 ± .071
Palo Alto	189 (paired)	.61 ± .035
San Jose Normal	79 (paired)	.51 ± .060
Palo Alto Sister–Sister	82	.51 ± .060
Palo Alto Brother–Brother	105	.40 ± .056
Palo Alto Brother–Sister	164	.34 ± .050
Average		.49

Merriam made an extensive study of twins using Stanford Binet, Army Beta, National Intelligence tests and teachers' ratings, in order to get measures and estimates of intelligence. His results, obtained by the Pearson formula, follow:

Stanford Binet I. Q.'s

	No. of Pairs	Pearson *r*
All Pairs, 5– 9 Years	47	.809 ± .032
All Pairs, 10–16 Years	58	.757 ± .037

Army Beta

	No. of Pairs	Pearson *r*
All Pairs, 5– 9 Years	28	.784 ± .049
All Pairs, 10–16 Years	48	.664 ± .054

National

	No. of Pairs	Pearson *r*
All Pairs, 5– 9 Years	54	.797 ± .034
All Pairs, 11–18 Years	89	.875 ± .017

[18] Merriam, C., "Intellectual Resemblance of Twins." *Psych. Rev.*, Monograph No. 152, 1924, pp. 1-58.

TEACHERS' RATINGS

	No. of Pairs	Pearson r
All Pairs, 5– 9 Years	39	.686 ± .057
All Pairs, 10–16 Years	51	.373 ± .081

For this part of the study, Merriam concluded that environment appeared to make no significant difference in the amount of twin resemblance.

Family resemblances beyond the first degree of relationship were studied by Dexter,[19] who used scholarship records as estimates of intelligence of pairs of cousins at the University of Wisconsin, and of pairs of cousins at Agnes Scott College. Another group was composed of school children who were given intelligence tests. The results were:

	No. of Pairs	Pearson r
University Cousins	201	.206 ± .045
College Cousins	64	.191 ± .081
Elementary School Cousins Average of One Test	131	.219 ± .059
Elementary School Cousins Average of Two Tests	135	.222 ± .057

STUDIES OF INHERITANCE OF ABILITY IN SCHOOL SUBJECTS

Several studies have been made of the inheritance of ability in school subjects. Earle [20] calculated resemblances for 180 pairs of brothers and sisters in spelling ability, and obtained a correlation of .50. Cobb [21] studied relationship between children and parents in the four fundamental operations in arithmetic and in copying figures. She found a tendency for a child's skill in any one process to be greater or less as the parent's skill in the process was greater or less than in another process. It was found that a child might resemble in this respect either but only one parent, and that a child showed a greater resemblance to a like parent than

[19] Dexter, E., "On Family Resemblances Beyond the First Degree of Relationship." *Sch.* and *Soc.*, Apr. 26, 1924, pp. 501-02.

[20] Earle, E. L., *The Inheritance of Ability to Learn to Spell.* Columbia Contr. to Phil., Psych., and Ed., Vol. 11, No. 2, pp. 41-44.

[21] Cobb, M. V., "A Preliminary Study of the Inheritance of Arithmetical Ability." *Jr. of Ed. Psych.*, Vol. 8, No. 1, Jan. 1917, pp. 1-20.

to the mid-parent. The conclusion was reached that the likeness must be due to heredity.

One study made by Starch [22] for resemblances of sibs both in intelligence and achievement has already been noted. In another study, the same writer studied resemblances of siblings in several school subjects and computed correlations by the Spearman rank method. He obtained results as follows:

Subject	No. of Pairs	r
Spelling	57	.21
Reading	57	.49
Writing Speed	24	.18
Writing Quality	24	.06

Eleven Seattle Families

Subject	No. of Pairs	r
Arithmetic	54	.32
Spelling	54	.21
Reading	54	.31
Language	54	.24

Starch concluded that abilities in the special subjects were inherited to no greater extent in one subject than in another. He believed that what was inherited was either general intelligence or more specialized traits than ability in arithmetic or language. He found no evidence for special abilities in certain subjects to run in families. He concluded that ability in school work was inherited to much the same extent as physical characteristics.

A general summary of the results and conclusions of the various studies is somewhat as follows:

1. In regard to the extent of association among related individuals:

a. Twins show the highest amount of resemblance. The amount varies from .62 to .90 when intelligence tests have been used in estimating intelligence.

b. Siblings show on the average less resemblance than twins. The amount appears to be on the average about .50, though it may vary greatly from this figure.

c. Cousins and other relationships beyond the first degree show still lower correlation than that found for sib-

[22] Starch, D., "The Inheritance of Abilities in School Studies," *Sch. and Soc.*, 1915, Vol. 2, pp. 608-10.

lings. It appears to be less than half the amount of sibling resemblance.

2. In regard to the cause of this resemblance, the consensus of opinion is that heredity rather than environment accounts for the greater share of this resemblance.

3. Mental traits appear to be inherited to about the same extent as physical traits.

4. Ability in school subjects seems to be hereditary to much the same extent as intelligence, though there is a conflict of opinion as to whether this applies only to special subjects or to all subjects in general.

The chief defect in the earlier studies is the lack of objective measures of mental traits. Objections to later studies which do employ objective measures of intelligence and achievement follow:

1. Lack of a sufficiently large enough number of cases for reliability of results and conclusions.

2. Restriction in range of talent within a group.

3. Lack of representative sampling of talent in the population at large.

4. Lack of uniformity in tests used for measuring intelligence.

5. Interpretations and comparisons of correlation coefficients at face value without making certain necessary reservations in view of such factors as restriction in range of talent and number of cases used.

6. Disregard of a possible factor of spurious correlation found in correlating I.Q.'s for different ages.

7. Too frequent guess work as to resemblance rather than actual computation of correlations of random pairings of unrelated children.

8. Interpretation of results without regard to possible variations in the means, standard deviations and other constants of various population samples.

No one of the studies summarized is free from one or more of these objections. In the present study an attempt will be made, in so far as possible, to overcome them. Furthermore, no study has been found in which the direct effect of environment in causing likenesses or differences in related and unrelated individuals has been determined. The present study will include an investigation of this phase of the problem.

CHAPTER III

DESCRIPTION OF THE POPULATION FROM WHICH SIBLING DATA WERE OBTAINED

In order to study that phase of the problem concerned with the presence or absence and amount of sibling resemblance, it was believed to be highly desirable to collect as much sibling data as possible from several diverse populations. This was done in order to discover any differences or similarities in results which might be due to different populations, and to obtain if possible an approximation to a normal distribution of sibling talent by forming a composite of the whole, so that the results might be as reliable as possible and the conclusions of wide application.

For investigating the third phase of the problem, the relative potency of heredity and environment in causing resemblances in siblings, it was decided to use data from a single large orphan asylum. The orphan population incidentally yielded data for the first two points of the investigation.

A description of the several populations will here be given, outlining the general characteristics of the groups, noting the selective factors operating in the populations, and comparing the groups so far as possible in regard to social and economic status, nationality predominating, and the like.

THE OKLAHOMA GROUP

A source of much reliable sibling data was that of an Oklahoma city of 25,000 population, resembling in many respects the typical city of its size throughout the country; in other respects, differing widely. The stock is largely native Anglo-American, though few of the citizens were actually born in the town. Nearly every inhabitant has come from an eastern, northern, or southern state. The Jewish and Italian races have few representatives in comparison with the rest of the population. The negro population is of substantial size, but does not affect this study since no records

of individuals of negro blood were available for it. Included in the population are some individuals of American Indian descent. The number of school children with varying degrees of Indian blood was not determined; it constitutes a small percentage of the whole. Several studies have been made of the intellectual status of the Indian in general. Garth [1] and Hunter [2] found that the individuals of mixed blood tend to have higher intelligence as measured by the tests than those of full blood. School children of full Indian blood in the Oklahoma population here described are few. What effect the individuals with mixed blood have upon the general distribution for the city in mental ability is not known, but the presence of some individuals of Indian descent in the population must be noted.

The occupations of the parents of a random selection of 608 school children of the same population were investigated by the writer. The occupations were classified in a fivefold category ranging from professional occupations to those of unskilled labor. Judging from this category, the distribution of occupations would appear to approximate a symmetrical curve. The occupations of parents, it may be concluded, are not of predominantly inferior or superior type, but represent, on the whole, average or moderate skill and ability. In this distribution, the occupations of a few Indians in the random selection, who are wealthy landowners, were eliminated since they did not fit into the general scheme of classification. There is a predominance of the oil operating industries, but since within these industries occupations may range from refinery superintendents, chemists and engineers, to unskilled labor, the predominance of these industries cannot be said to influence the general curve of distribution of occupations more one way than another. It may be concluded, therefore, that in general, so far as occupational status is concerned, this city cannot vary much from the average status of American cities of its size in general. Beggars and millionaires are few or lacking. The economic status of most of the citizens must be described as average. Educational institutions are of the best,—in general, superior to those of the country as a whole. The usual number of churches, libraries, and civic clubs is to be found. We may,

[1] Garth, T. R., "A Comparison of Mental Abilities of Mixed and Full Blood Indians on a Basis of Education." *Psych. Rev.*, Vol. XXIX, No. 3, pp. 221-36.

[2] Hunter, W. S., "The Relation of the Degree of Indian Blood to Score on the Otis Intelligence Test." *Jr. Comparative Psych.*, Vol. II, No. 3, pp. 257-77.

therefore, conclude that a random selection of children from this community should be comparable in many respects to a random sampling of children from the average American community.

THE HORACE MANN SCHOOL GROUP

Another source of data used was that of the Horace Mann School, Teachers College, Columbia University, New York City. Representatives of this group differ in many respects from those of the Oklahoma community. The large majority of children in this school come from homes of superior economic, social, and intellectual status. The tuition fee charged automatically excludes children of parents of the poorest economic status. Some of the pupils are children of professors and graduate students of Columbia University, making for selection of the better intellectual ability. In general, the environment of the children both in and out of school is decidedly superior to that of the average American child. Any random sampling, consequently, of these children would represent only one end of the normal distribution of school children in general of the United States. Here again the predominant racial stock is Anglo-Saxon, although representatives of the Jewish race are frequent, and there is a small scattering of many nationalities, including Japanese, French, Dutch, German, and others.

THE HEBREW ORPHANS GROUP

The Hebrew Orphan Asylum of New York City was chosen for a number of reasons in making the desired study of siblings and foster-siblings. Wards of this institution are of Hebrew stock, either native or foreign born. The majority of the children are natives of New York City. Children are received at any age above five years, and may or may not be boarded out in suitable homes. The younger children attend school within the institution, the others attend neighboring grade schools, high schools, and business and trade schools throughout the city. Probably in the majority of cases one or both parents are living, but for reasons of economic stress, ill health, incompatibility, and the like, one or more of the children in a family are received into the institution. The intellectual status as judged by the mental ability of the children is about average. (The average I.Q. is about 95.) A reading of the case histories of many families

contributing one or more children to the institution reveals so many almost unbelievable stories of sordid lives, squalid, wretched homes, cruel, immoral, abnormal parents, that one is forced to the conclusion that the homes represented are far below the average of Jewish parents and homes in general, and that the economic, social, and moral status represents a very low stratum of the Jewish population. This is not surprising, for it is to be expected that orphans are drawn from maladjusted rather than from well-adjusted homes, and the reason for the lack of adjustment is usually to be found in the parents. The superintendent of the asylum, speaking in reference to his wards, remarked most emphatically that a new race must be built up. These selective factors must be kept in mind in the interpretation of results based upon data obtained from this group. As will be seen later, the general homogeneity of the group as far as racial and other factors are concerned proved to be advantageous in carrying on the proposed study.

CHAPTER IV

THE DATA

In order to make the entire study as reliable and uniform as possible, it seemed highly desirable to include in the data records of those individuals only who had been given individual Binet examinations for measuring mental ability. Other records were available in many cases, but they were not included, in the interests of greater homogeneity of data. No chronological age restrictions were imposed, except such as those which operate automatically in the school and orphan populations. Records of both sexes were included, and there was no exclusion of available records on the basis of racial factors. The specific data obtained for each group, the selective factors operative in the data, and the intelligence and chronological age distributions for each group will now be described separately and in the following order: (*a*) Oklahoma, (*b*) Horace Mann, (*c*) Hebrew orphans.

DATA FOR THE OKLAHOMA GROUP

Special classes are maintained in the city school system for bright and dull children in the grade schools. Before admission to these classes, each child who is considered a possible candidate is given an individual Binet examination. In general, then, the average child is not given an individual test, except as he has been misjudged by teacher, supervisor, or examiner. In fact, the average child is avoided so far as possible in the interests of economy of the examiner's time. In spite of this fact, it can be seen quite readily from the I.Q. distribution in Table I, page 36, that many normal and average children are examined. For several years previous to the collection of sibling data, intelligence records of pupils had been accumulating. About 80 per cent of the intelligence records were based on the Stanford Revision of the Binet examination. The remainder were based on the Goddard and Kuhlmann revisions. Stanford retests of many children examined earlier by the Goddard and Kuhlmann re-

visions were made. In this study, the data reported are based in 98 per cent of the cases on the Stanford Revision. The remainder of the measurements are based on the Kuhlmann revisions. Since the Stanford examinations predominated in the initial collection of the data, the Stanford was preferred throughout to preserve the greatest homogeneity; it was not preferred because the Stanford I.Q.'s were considered superior to those of any other revision of the test. With the restrictions given above in mind, all of the sibling data available were collected. No testing was done for the purpose of obtaining more data. About 90 per cent of the examinations were made by one examiner, the writer. The other examinations were made by four other examiners.

For each child, the following data were collected: Name, date of birth, I.Q., chronological age at the time of test, mental age at the time of test, sex, grade, school, parents' address, parents' occupation, names of other brothers and sisters. For some children, Stanford Achievement Test records were available. In these cases, the further data collected were: chronological age at the time of the Achievement Test, composite score on the test, educational age based on the composite score, educational quotient, and accomplishment quotient.

Many of the families were known to the writer. Consequently, in these cases the task of determining whether or not the children believed to be sibs actually were true sibs was simple. In cases where there was doubt, and the actual relationship was not known to the writer, the necessary information was obtained from teachers, supervisors, school nurse, and attendance officer. Every precaution was taken to eliminate foster sibs. A few cases of twins were available. These were, however, eliminated. The number of cases was too few to justify a special study of them.

All of the children included in the investigation except two were pupils in the public schools at the time of the mental examination. The two who were not, a boy and a girl with I.Q.'s of 35 and 27 respectively, had never appeared at school. These children were examined in their homes for the purpose of evidence for commitment to institutions.

Concerning the technique of administering the Stanford mental examinations, it will suffice to say that the procedure as set forth by Terman [1] was followed closely. The practice of considering

[1] Terman, L. M., *The Measurement of Intelligence.*

no test complete until levels had been reached in which all tests were passed, and in which all tests were failed was adhered to. Both series of words in the vocabulary test were given in practically all cases. In the case of the few children over sixteen years of age at the time of the test, the mental age gained in the test in terms of years was divided by 16. All of the tests were given within a four-year period,—most of them within two years.

An examination of the distribution of I.Q.'s in Table I reveals the following facts:

Lowest I.Q.	27
Q_1	71.7
Median I.Q.	87.92
Q_3	102.70
Highest I.Q.	145
No. of cases	671

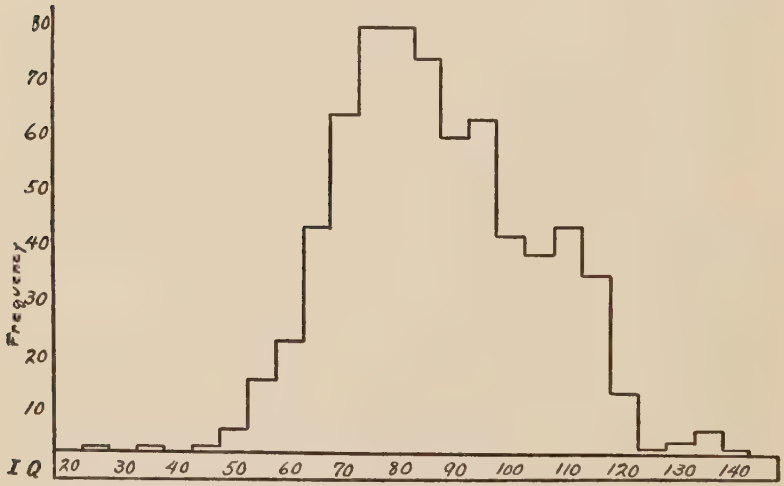


Fig. I. Distribution of Intelligence Quotients—Oklahoma

Figure I shows the distribution in the form of a histogram. The distribution in Figure I may be observed to be moderately asymmetrical. The number of cases for each step interval of 5 points of I.Q. from 100 to 120 is fairly uniform, following which there appears to be quite a sudden slump in the number of cases.

Lowest C.A.	5 years 6 months
Q_1	9 years 11 months
Median C.A.	11 years 10 months
Q_3	13 years 3 months
Highest C.A.	18 years 0 months
No. of cases	671

The chronological age distribution in Table II which is shown grapically in Figure II may be summarized as follows:

The curve shows a slight tendency toward bimodality at the points around 9 to 10 years and 12 to 13 years on the base line.

A few words of explanation will make clear some of the reasons for the peculiarities of the I.Q. and chronological age distributions as they appear in the tables.

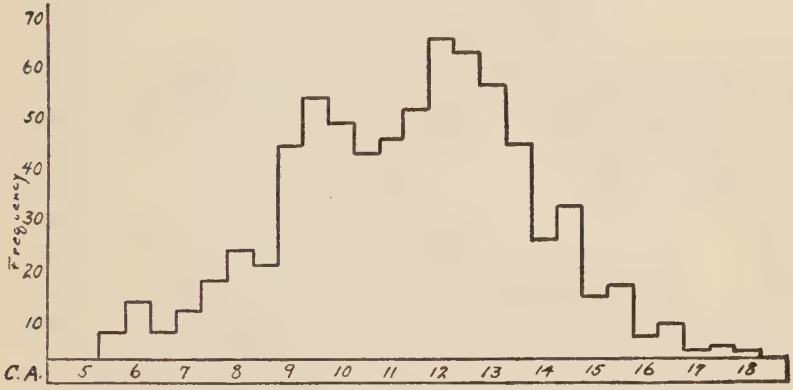


Fig. II. Distribution of Chronological Ages—Oklahoma

Bright children were tested much less frequently than the dull for several reasons. In the first place, there were fewer classes for the bright than for the dull. For the dull, special classes and sections were provided from the first grade through the junior high school. All children in the school system who had reached the age of thirteen without getting through the sixth grade were brought together into special classes, and grouped according to intelligence. This necessitated the testing of all of these children. Classes for the bright were provided only from the fourth grade through the junior high school. Other reasons for the fewer number of bright children are that they are less problematical in a school system; they are therefore less readily discernible, and the teachers dislike to part with them when they discover their

ability. Their frequent under-ageness also prevents their ready detection on the part of teachers and supervisors. A further reason is found in the fact that brighter children tend to have fewer sibs, who have been tested within a four-year interval, than the dull children. Some of the brightest children, it was observed, had no sibs of school age who had been tested.

Whether the fact that testing was done only at the request of teachers and school officials under the conditions mentioned, and not directly for purposes of the study, caused like sibs to be tested more frequently than unlike sibs, is difficult to determine. It is possible that there was a slight tendency toward such selection, but the extent of its influence on the data is not known.

THE HORACE MANN GROUP

For this group all of the data obtained for the study were on file in the school offices at the time the investigation was begun. For this group, also, no testing was done for the express purpose of getting sibling data. Each Horace Mann pupil is given an individual mental examination (Stanford Binet) as a part of his record. None of the examinations were made by the writer. The examinations extend chronologically over a period of nearly ten years. They were administered by some twenty-five or more different examiners of varying degrees of training and experience. The majority of the examinations, however, were made by probably not more than three or four examiners. The data collected for each child were: Name, date of birth, chronological age at the date of the test, mental age at the date of test, I.Q., grade, sex, parents' names. Some data from tests of school subject attainment were available and were included. The test used was the Stanford Achievement in part. A composite educational age comparable with the educational age for the test was computed. Educational and accomplishment quotients were also computed.

Inspection of the distribution of Horace Mann I.Q.'s in Table I discloses these facts:

Lowest I.Q.	70
Q_1	108.75
Median I.Q.	118.55
Q_3	128.55
Highest I.Q.	170
No. of cases	523

The same distribution is shown by the histogram of Figure III.

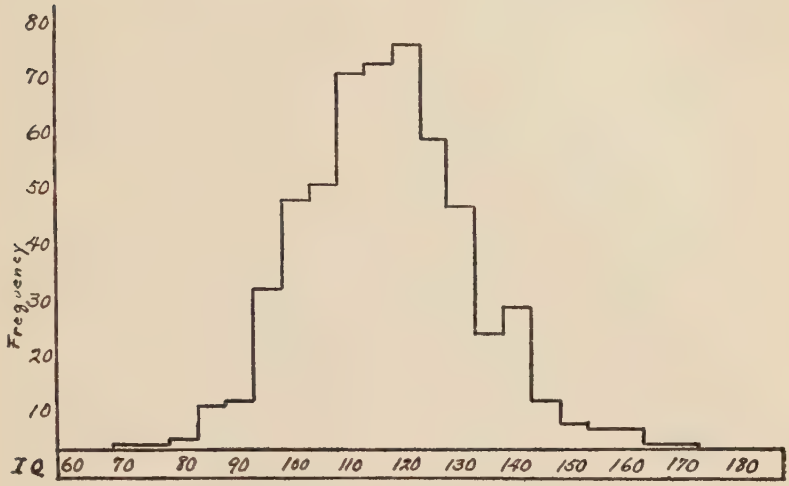


FIG. III. DISTRIBUTION OF INTELLIGENCE QUOTIENTS—HORACE MANN

For the distribution of the chronological ages, the results in Table II are:

Lowest C.A.	3 years
Q_1	5 years, 2 months
Median C.A.	7 years, 5 months
Q_3	9 years, 8 months
Highest C.A.	14 years
No. of cases	523

The histogram of Figure IV shows the same distribution.

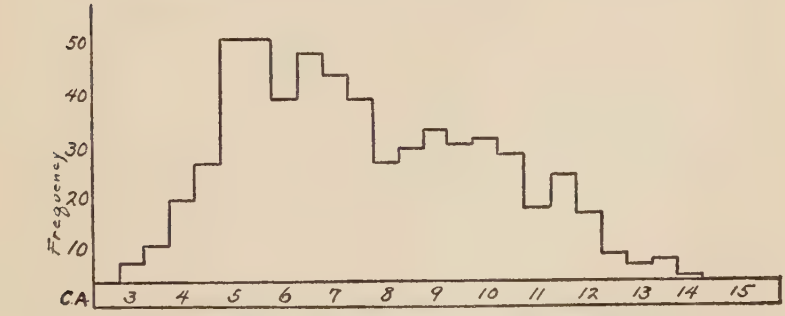


FIG. IV. DISTRIBUTION OF CHRONOLOGICAL AGES—HORACE MANN

The tendency for the lower chronological ages to predominate is due to the fact that children are tested as soon after entrance as possible. The average intelligence is higher than the average for school children in general, because of the selective agencies at work in the school. These data very nicely supplement the Oklahoma data, but here again the normal child is seldom included; hence, joining the two distributions does not mean that a normal distribution is thereby obtained.

The number of siblings from the same family who have been sent to the school during the ten-year period is on the average small. Families of four children attending the school during ten years are rare. It might be possible that parents tend to send the duller children to other schools than Horace Mann School. Children below average intelligence tend to be excluded from that school.

HEBREW ORPHAN ASYLUM DATA

Since the purpose of investigating these records and of getting data of these children was only incidentally to get information concerning resemblances in true sibs, but was mainly for the investigation of unrelated children reared together and related children reared apart, more information was necessary about each child than was required for individuals in either of the other groups. The data obtained were therefore: name, date of birth, birthplace, chronological age at the time of test, mental age at the time of test, intelligence quotient, date of admission to the institution, place admitted from, length of stay in the institution, date of discharge, place or people discharged to. In many cases in which there was history of prior residence in other institutions, the date of admission, length of stay, date of discharge, and name of place or people discharged to, was obtained for these institutions as well. When all the facts were put together, they yielded a fairly exact picture of the child from the time the first records were made. When a child was recorded as having been boarded out, the length of stay was, of course, noted, but the character of the environment into which the child had been placed in most cases could not be well determined from the record.

For this group, also, all of the records were on file at the time the investigation was begun. No testing was done for purposes

of the experiment. For the past few years, intelligence testing has been a part of the institutional routine. All of the children who stay long enough eventually receive intelligence tests. Again, the data are restricted to Stanford Binet examinations. No achievement test records were available. The majority of the examinations were made by one person, a psychologist, on the staff of the institution.

The I.Q. distribution of Table I shows these facts:

Lowest I.Q.	60
Q_1	85.15
Median I.Q.	96.15
Q_3	104.8
Highest I.Q.	140
No. of cases	346

The same distribution is shown by the histogram of Figure V.

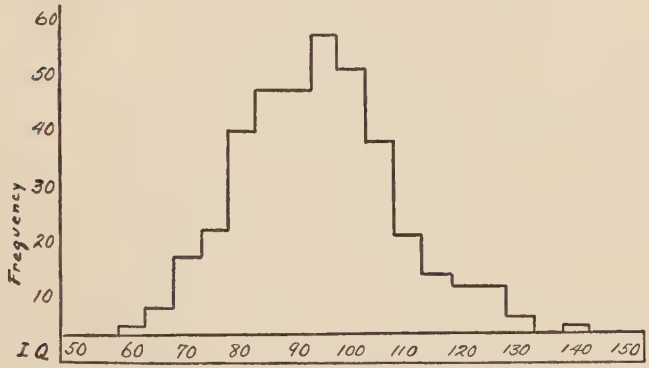


Fig. V. Distribution of Intelligence Quotients—Hebrew Orphans

The distribution as shown in Table II is fairly normal and compact:

Lowest C.A.	4 years
Q_1	8 years, 0 months
Median C.A.	9 years, 11 months
Q_3	11 years, 7 months
Highest C.A.	15 years
No. of cases	346

Figure VI shows the same distribution in the form of a histogram.

The distribution tends rather away from the symmetrical bell-shaped curve, to a rectangular distribution.

A composite of the I.Q. data (Table I) reveals a similarity to a normal distribution. It is probable, however, that even with

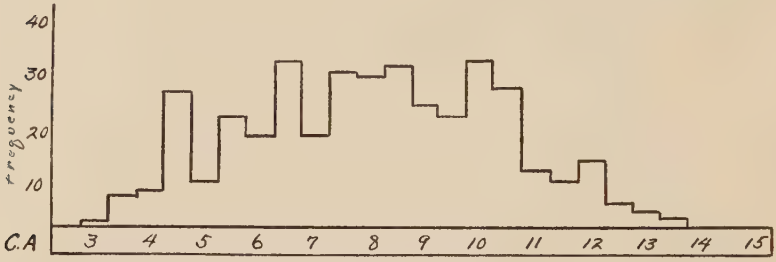


FIG. VI. DISTRIBUTION OF CHRONOLOGICAL AGES—HEBREW ORPHANS

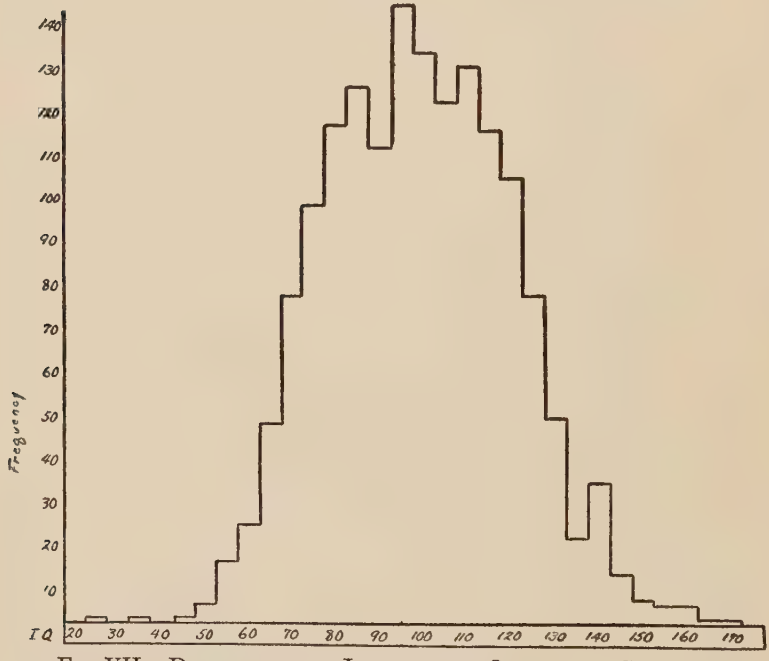


FIG. VII. DISTRIBUTION OF INTELLIGENCE QUOTIENTS—COMPOSITE

the addition to the composite of the Hebrew Orphan group, containing many normal children, there is an insufficient proportion of normal children to meet the requirements of the curve upon which the tests were standardized.

The same distribution is shown in Figure VII. Table II and Figure VIII show the distributions for the composites of I.Q.'s and C.A.'s.

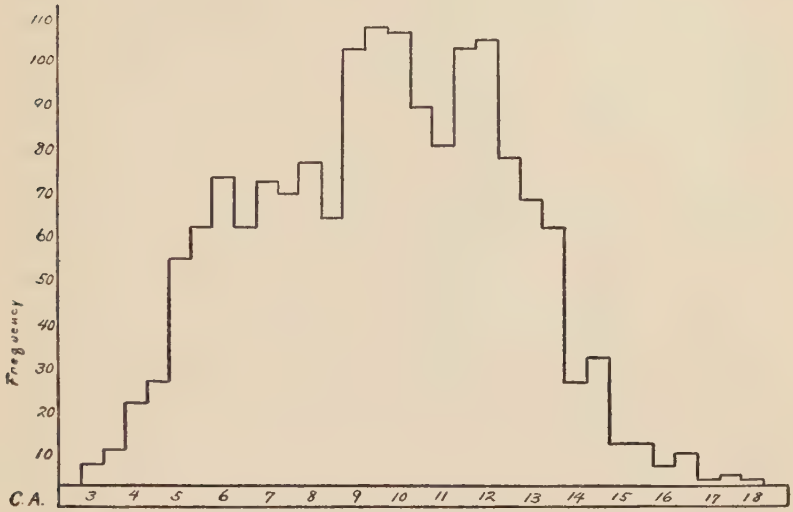


FIG. VIII. DISTRIBUTION OF CHRONOLOGICAL AGES—COMPOSITE

In addition to the data that have been described, brief case history records were also obtained for a few of the Oklahoma families in order that more light might be thrown upon some of the peculiarities of resemblance and difference that were found. These facts were collected merely for the purpose of supplementing the study. They are not to be considered worthy of taking the place of the actual objective measurements.

In arranging the data for statistical treatment, each family was listed in alphabetical order. The arrangement of the siblings in any one family was, however, chance. That is, the child placed first in the list of any one family was not necessarily the youngest, oldest, brightest, or dullest, boy or girl.

Throughout the three groups, any individual for whom there were data which were questionable or in any respect lacking, necessitated the exclusion of that individual from the study. For that reason the number of sibling cases in each group is somewhat more restricted than is actually the case.

TABLE I

DISTRIBUTION OF INTELLIGENCE QUOTIENTS

I. Q.	Oklahoma	Horace Mann	Hebrew Orphans	Composite
25	1	--	--	1
30	--	--	--	--
35	1	--	--	1
40	--	--	--	--
45	1	--	--	1
50	4	--	--	4
55	13	--	--	13
60	20	--	2	22
65	41	--	5	46
70	61	1	13	75
75	76	1	19	96
80	76	2	36	114
85	71	8	43	122
90	57	9	43	109
95	60	29	53	142
100	39	45	47	131
105	36	48	35	119
110	41	68	18	127
115	32	69	11	112
120	22	73	8	103
125	11	56	8	75
130	1	43	3	47
135	2	21	--	23
140	3	26	2	31
145	2	9	--	11
150	--	5	--	5
155	--	4	--	4
160	--	4	--	4
165	--	1	--	1
170	--	1	--	1
Lowest	27	70	60	27
Q_1	71.7	108.75	85.15	80.49
Median	87.92	118.55	96.15	95.92
Q_3	102.70	128.55	104.8	111.4
Highest	145	170	140	170
N	671	523	346	1540

TABLE II

DISTRIBUTION OF CHRONOLOGICAL AGES

C. A. Years and Months	Oklahoma	Horace Mann	Hebrew Orphans	Composite
3	--	4	--	4
3–6	--	7	--	7
4	--	17	1	18
4–6	--	23	--	23
5	--	47	5	52
5–6	5	47	6	58
6	11	36	24	71
6–6	5	45	8	58
7	9	41	20	70
7–6	15	36	16	67
8	21	23	30	74
8–6	18	26	17	61
9	42	30	28	100
9–6	51	27	27	105
10	46	28	29	103
10–6	40	25	22	87
11	43	14	20	77
11–6	49	21	30	100
12	63	13	25	101
12–6	60	5	10	75
13	54	3	8	65
13–6	42	4	11	57
14	23	1	4	28
14–6	30	--	3	--
15	12	--	2	--
15–6	14	--	--	--
16	4	--	--	--
16–6	7	--	--	--
17	2	--	--	--
17–6	3	--	--	--
18	2	--	--	--
Lowest	5–6	3	4	3
Q_1	9–11	5–2	8	7–8
Median	11–10	7–5	9–11	9–6
Q_3	13–3	9–8	11–11	12–1
Highest	18	14	15	18
N	671	523	346	1540

CHAPTER V

STATISTICAL PROCEDURE

METHOD OF PAIRING TRUE SIBS

For a number of families of all the groups, records were obtained for more than two children in the family. This necessitated a decision as to the proper method of pairing the siblings in these cases before any methods for computing relationship could be applied. No precedent had been established by the earlier studies. Some writers do not describe the methods of pairing used if they encounter such cases. Gordon, it will be recalled, dropped the youngest pair in a family of three, and made only two pairs of a family of four. This method reduces the number of possible pairs. Galton describes his method of meeting this situation as follows: "The tables were constructed by registering the differences between each possible pair of brothers in each family: thus, if there were three brothers in a particular family, I entered the differences in stature between A and B, A and C, and B and C. Four brothers gave rise to six entries, and five brothers to ten entries. The larger fraternities were omitted, as the very large number of different pairs in them would have overwhelmed the influence of the smaller fraternities. Large fraternities are separately dealt with. . . ."[1]

In regard to the same point, Yule says, "In certain cases, a correlation table is formed by combining N observations in pairs in all possible ways. If, for example, a table is being formed to illustrate, say, the correlation between brothers for stature, and there are three brothers in one family, 5 ft. 9 in., 5 ft. 10 in., 5 ft. 11 in., these are regarded as giving the six pairs:

5 ft. 9 in. with 5 ft. 10 in.	5 ft. 10 in. with 5 ft. 9 in.
5 ft. 9 in. with 5 ft. 11 in.	5 ft. 11 in. with 5 ft. 9 in.
5 ft. 10 in. with 5 ft. 11 in.	5 ft. 11 in. with 5 ft. 10 in.

[1] Galton, F., *Natural Inheritance*, p. 92.

which may be entered into the table. The entire table will be formed from the aggregate of such subsidiary tables, each due to one family." [2]

An empirical attempt was made in the present study to determine the difference between taking the maximum number of pairs and the method of dropping excess sibs. In the Oklahoma group, 300 families are represented by two or more siblings. The maximum number of pairs is 450. The r computed for the 450 pairs ($r = .629 \pm .02$) differed from the r computed for one pair from each of the 300 families ($r = .639 \pm .02$) by .010. This difference could be due to sampling in the case of the 300 pairs, and is probably wholly due to chance. The standard deviations for each of the three groups computed for both methods of pairing showed very slight differences only. Elderton [3] in computing correlations for Gordon's data, using both Gordon's method of pairing and the method of total number of pairs, obtained varying degrees of differences between the correlations computed by both methods; some were negligible differences,—others were of greater size.

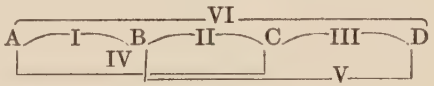
In the present study the method of forming the correlation tables from the total number of pairs has been used throughout.

DIAGRAM OF METHOD OF PAIRING IN THE CASE OF THREE OR MORE SIBLINGS IN A FAMILY

Family of 3 Sibs

I AB
II BC
III AC

Family of 4 Sibs



I AB
IV AC
VI AD
II BC
V BD
III CD

Galton [4] pointed out that large fraternities paired in all possible ways and entered into the total table, might tend to weight the entire table too much in one direction.

In the present study this danger would obviously be less in the first two groups than in the third because of the predominance of the larger fraternities in the orphan group.

[2] Yule, G. U., *Introduction to the Theory of Statistics*, p. 217.
[3] Elderton, E., "A Summary of the Present Position with Regard to the Inheritance of Intelligence." *Biometrika*, 1923, 14, pp. 378-408.
[4] Galton, F. H., *Natural Inheritance*.

The fraternities range in size and number as follows:

Group	Number of Sibs in Each Family				Total Families	Total Pairs[5]
	2	3	4	5		
Oklahoma	241	48	11	--	300	450
Horace Mann	204	33	4	--	241	325
Hebrew Orphans	103	34	8	1	146	253

METHODS OF COMPUTING RESEMBLANCE

Several methods were available for determining the resemblances between siblings. The method adopted was that of computing correlations of I.Q.'s by means of the Pearson product-moments formula:

$$r = \frac{\frac{\Sigma xy}{n}}{\sigma_x \sigma_y}$$

for correlations of zero order. The r measures the extent of resemblance of pairs of siblings in the capacities measured.

Another method of showing the relationship between pairs of sibs, the method of mean differences, was also used in order to bring out the essential facts of the data. The method is to compute the amount of difference between each pair, sum the differences and divide the sum by the number of cases,—in other words, to take the average of the differences. A short cut to the same result which was used in cases involving more than 100 pairs, was that which utilizes the principle that the average of the sum or difference of two series of measures is equal to the sum or difference of their averages. Yule [6] shows, "The mean of all the sums or differences of corresponding observations in two series (of equal numbers of observations) is equal to the sum or difference of the means of the two series."

By comparing the average differences of true sibs with those of non-sibs, some idea of their relationship may be obtained. The reliabilities of these differences were not computed.

[5] The number of pairs obtained does not tally with the number to be obtained by straight calculation from the figures given. In all three groups, twins were included when there were other sibs in the family, but twins were never paired together. In the Orphan group, in one family of four siblings and another of five siblings, the only pairs chosen were of those sibs who had been reared together.

[6] Yule, G. U., *Introduction to the Theory of Statistics*, p. 115.

The method of partial correlation was also used in part of the study, in order to compute the resemblances of siblings in mentality when the factor of differences in chronological age is eliminated. It was used in an attempt to eliminate any factor of spurious correlation which may result from the correlation of intelligence quotients for children of different ages, to which attention has been called by Pintner and Thomson.[7] The following formula and diagram give a description of the structure of the partial r in four variables. (Table III.)

TABLE III

STRUCTURE OF THE PARTIAL r IN FOUR VARIABLES

I	$r_{12} = MA_1\ MA_2$	I	CA_1 MA_1 / CA_2 MA_2
II	$r_{13} = MA_1\ CA_1$	II	CA_1 — MA_1 / CA_2 MA_2
III	$r_{23} = MA_2\ CA_1$	III	CA_1 MA_1 / CA_2 — MA_2
IV	$r_{14} = MA_1\ CA_2$	IV	CA_1 — MA_1 / CA_2 MA_2
V	$r_{24} = MA_2\ CA_2$	V	CA_1 MA_1 / CA_2 — MA_2
VI	$r_{34} = CA_1\ CA_2$	VI	CA_1 MA_1 / CA_2 MA_2

In each case the r computed was $r_{12 \cdot 34}$, that is, $r_{MA_1MA_2 \cdot CA_1CA_2}$ in which MA_1 is the mental age of the first of a pair of siblings (whether oldest or youngest, brightest or dullest, boy or girl, it will be recalled, would be a matter of pure chance), MA_2, the second of a pair. In like manner, CA_1 is the chronological age at the time of the test for the first child of a pair listed, and CA_2, the chronological age of the second child listed.

In computing the correlations and average differences (by the short method) it was necessary to decide upon suitable step intervals for I.Q., C.A., and M.A. For the computation of the correlations and differences of the three separate groups, step intervals of 5 points of I.Q. and 6 months of age were chosen. For computing correlations and differences for the composite of all the groups thrown together, step intervals of 10 points of I.Q. and 1 year of age were chosen. This change was necessary because of the extremely large ranges of I.Q., C.A., and M.A.

[7] Pintner, R., and Thomson, G., "Spurious Correlation and Relationship Between Tests." *Jr. Educ. Psych.*, Vol. XV, No. 7, pp. 433-44.

found in the composite. The probable errors of the correlations were not computed but were taken directly from the tables prepared by Toops and Miner.[8] Likewise, the values of $\sqrt{1-r^2}$ involved in the partial correlations were read directly from Miner's [9] tables.

METHODS OF RANDOM PAIRING

It seemed desirable to substantiate the fact that the correlation of random pairings of non-sibs is in every case equal to zero, with actual computations of random pairings for each group. The method of random pairings was as follows: Each family had been entered in the data sheets in alphabetical order. Each child was numbered consecutively in the order in which he appeared on the sheet, for example:

Family	Child	Number
A	L	1
	E	2
	Y	3
B	M	4
	A	5
C	J	6
	Z	7

In order to choose pairs at random, every tenth child was chosen throughout the list and pairs were made up as follows: 1 and 11, 21 and 31, 41 and 51, throughout the list. If more pairs were desired, pairs were composed of 2 and 12, 22 and 32, 42 and 52, etc.

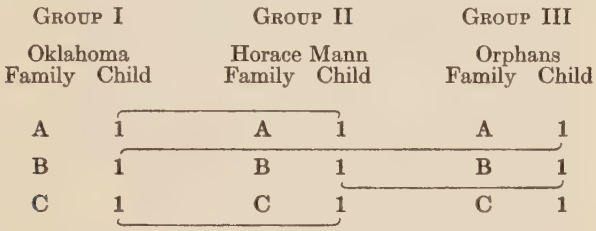
It was further decided, as another method of comparing true siblings and non-siblings, to choose a number of pairs of true sibs and match them for sex and chronological age with children chosen at random so far as I.Q.'s were concerned. Thus, for example, for the true sib pair, L. H. (girl, C.A. 10-6) and A. J. (boy, C.A. 8-3), another pair of children of the same sex and chronological ages was chosen. These were obtained by taking the first child in the list after the child for whom a match was sought, with the same sex and chronological age.

[8] Toops, H. A. and Miner, Z., "A Serviceable P. E. *r* Table." Reprint from *Jr. of Educ. Res.*, Jan. 1924.

[9] Miner, J. R., *Tables of* $\sqrt{1-r^2}$ and $1-r^2$ for *Use in Partial Correlation and in Trigonometry*, The Johns Hopkins Press, Baltimore, 1922.

In order to obtain random pairings for the composite of all the groups, two different methods of selection were used. The first method was as follows:

The data sheets for the three groups were placed side by side. The families had been listed on the sheets in alphabetical order. Child number one from the first family in one group, was paired with child number one, family one in group two. Child number one in family one, group three, was then paired with child number one, family two, group one; and so on throughout the list until the desired number of pairs was obtained. For example, the first few pairings might have been as shown in the diagram:



By this method, equal proportions were drawn from each of the three groups and no two children within one group were ever paired together. The objection could be raised to this method that it tends deliberately to seek the greater dissimilarities, since one child of one group is always paired with one child in another of the groups. To overcome this objection, a second method of pairing was used. All of the families of the three groups were arranged in alphabetical order. The first child in a family was then paired with the first child of the next family in order. By this method, two children within any one group occasionally chanced to be paired together.

In all cases of random pairings within a group or for a composite of all groups, the number of pairings was arbitrarily limited to 100 if data were available for so many pairs. Otherwise, 50 pairs were chosen from the available data.

LIST OF COMPUTATIONS MADE

A detailed list of the correlations computed follows:

A. To determine the amount of resemblance in I.Q.'s of pairs of true siblings and non-siblings.

1. Oklahoma
   - r_{xy} for maximum number of pairs.
   - r_{xy} for one pair from each of the 300 families represented.
   - r_{xy} for maximum number of pairs.
   - r_{xy} for random pairings.
   - r_{xy} for non-sibs matched to pairs of true sibs.
   - r_{xy} for the pairs of true sibs for whom matchings were sought.
   - r_{xy} for pairs for whom E. Q.'s were available.

2. Horace Mann
   - r_{xy} for maximum number of pairs.
   - r_{xy} for one pair from each family.
   - $r_{12 \cdot 34}$ for all pairs.
   - r_{xy} for random pairings.
   - r_{xy} for non-sibs matched to pairs of true sibs.
   - r_{xy} for the pairs of true sibs for whom matchings were sought.
   - r_{xy} for pairs for whom E. Q.'s were available.

3. Hebrew Orphan Asylum
   - r_{xy} for maximum number of pairs of true sibs reared together.
   - r_{xy} for one pair from each family.
   - $r_{12 \cdot 34}$ for all pairs.
   - r_{xy} for random pairing of unrelated children not reared together.
   - r_{xy} for true sibs and their corresponding unrelated pairs (matching).

4. Composite of Oklahoma, Horace Mann, and Hebrew Orphan true sibs
   - r_{xy} for maximum number of pairs.
   - r_{xy} for random sampling of unrelated pairs.
   - $r_{12 \cdot 34}$ for maximum number of pairs.

B. To determine the amount of resemblance of siblings in educational attainment. E.Q.'s

1. Oklahoma
   - r_{xy} for true sibs, maximum number of pairs.
   - r_{xy} for random pairings.

2. Horace Mann
3. Composite Oklahoma and Horace Mann
   r_{xy} for true sibs, maximum number of pairs.
   r_{xy} for random pairings.
   r_{xy} for true sibs, maximum number of pairs.
   r_{xy} for random pairings.

C. To determine the amount of resemblance of siblings in accomplishment or effort. A.Q.'s

1. Oklahoma
   r_{xy} for true sibs, maximum pairs.
   r_{xy} for random pairings.
2. Horace Mann
   r_{xy} for true sibs, maximum pairs.
   r_{xy} for random pairings.
3. Composite
   r_{xy} for random pairings.
   r_{xy} for true sibs, maximum number of pairs.

D. To find resemblance of true sibs reared apart.

   r_{xy} for maximum number of pairs.
   r_{xy} for one pair in each family.

In addition to these correlations, average differences for the following pairings were computed:

A. I.Q.'s

1. Oklahoma
   a. True sibs—all pairs.
   b. True sibs—300 pairs.
   c. Random pairings.
   d. True sibs matched.
   e. Pairings of unrelated children matched to true sibs.
2. Horace Mann
   a. True sibs—all pairs.
   b. Random pairings.
   c. True sibs matched.
   d. Pairings of unrelated children matched to true sibs.
3. Hebrew Orphans
   a. True sibs—all pairs.
   b. Random pairings.

c. True sibs matched.
d. Pairings of unrelated children matched to true sibs.

B. E.Q.'s
1. Oklahoma
a. True sibs.
b. Random pairings.
2. Horace Mann
a. True sibs.
b. Random pairings.

C. A.Q.'s
1. Oklahoma
a. True sibs.
b. Random pairings.
2. Horace Mann
a. True sibs.
b. Random pairings.

The variability of unrelated children reared together was computed for two groups:

(1) Those reared together, 10-25% of life;
(2) Those reared together, 50-100% of life.

The variability of the distribution of unrelated children reared apart was also computed.

METHOD OF CORRECTING FOR RESTRICTED RANGE

It can be observed and has frequently been demonstrated that increasing the range of distribution of the group from which a sampling of data for the computation of an r is selected, generally tends to increase the size of the correlation coefficient. Examples are given by Herring.[10] Correlations must therefore be interpreted with regard to the ranges of the data on which they are based, and where comparisons between coefficients are desired for varying population groups, as in the present study, corrections of the correlations for the factor of restricted range are desirable. A formula for correction applicable to this study is given by Kelley.[11] The formula is as follows:

$$\frac{\sigma}{\Sigma} = \frac{\sqrt{1-R}}{\sqrt{1-r}}$$

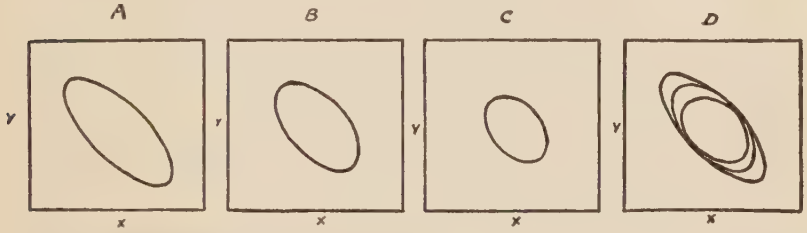
[10] Herring, J., "Avery's Comparison of the Stanford and Herring Revisions." *Jr. of Educ. Psych.*, Vol. XV, Sept. 1924, pp. 383-88.
[11] Kelley, T., *Statistical Method*, p. 222.

Solving for R,

$$R = \frac{\Sigma^2 - \sigma^2 (1 - r)}{\Sigma^2}$$

σ is the symbol for the standard deviation of the curtailed range; Σ is the standard deviation for the uncurtailed range; r is the symbol for the correlation coefficient obtained from the data of restricted range. R represents the new coefficient for uncurtailed range.

The following diagrams will make the problem clearer. Suppose Diagrams A, B, and C to represent the scattergrams for three sets of data with similar means but varying standard deviations. It can be seen at once that the A group represents a wider range of talent than the other two, whereas the C group represents a much more restricted range. Diagram D shows Diagrams A, B, and C superimposed. It can be seen from the appearance of the diagrams that the correlation coefficient increases as restrictions of range are removed.



The constancy of the I.Q. has in no part of the study been assumed. It would be possible to assume it and to derive measures for correlation which would obviate many of the difficulties encountered in using other measures. It was, however, considered unsafe to assume the constancy of the I.Q. until further study of the subject substantiates the assumption.

I.Q.'s for children tested above 14 years of age are believed to be more unreliable than those below 14 years. Such children are but a small proportion of the Oklahoma group and enter rarely or not at all in the other two groups. They were not eliminated, since it is difficult to draw the line at any one age and decide that I.Q.'s on one side are unreliable, those on the other are not. In the case of this study any error that is introduced into the results by such data is small.

CHAPTER VI

RESULTS

THE results obtained concerning the amount of resemblance in pairs of true sibs and in random pairings of unrelated children are as follows:

A. True Sibs

1. Intelligence (I.Q.'s)

a. All pairs

	Total r	Partial r	Mean Difference	No. of Pairs
Oklahoma	.629 ± .02	.474 ± 02	12.07	450
Horace Mann	.274 ± .03	.0751 ± .04	14.02	325
Hebrew Orphans	.322 ± 04	.127 ± .04	12.70	253
Composite	.679 ± .01	.419 ± .02	12.93	1028

b. One pair in each family

	Total r	No. of Pairs
Oklahoma	.639 ± .02	300
Horace Mann	.261 ± .04	241
Hebrew Orphans	.414 ± .04	146
Composite	.676 ± .01	687

2. Achievement (E.Q.'s)

	Total r	Mean Difference	No. of Pairs
Oklahoma	.579 ± .04	13.05	105
Horace Mann	.418 ± .06	11.93	83
Composite	.579 ± .03	12.49	188

For corresponding I.Q.'s

	Total r	No. of Pairs
Oklahoma	.647 ± .04	105
Horace Mann	.312 ± .07	83
Composite	.657 ± .03	188

3. Accomplishment (A.Q.'s)

	Total r	Mean Difference	No. of Pairs
Oklahoma	.269 ± .06	9.52	105
Horace Mann	.156 ± .07	10.90	83
Composite	.320 ± .04	10.21	188

B. Random Pairs

1. Intelligence

	Total r	Mean Difference	No. of Pairs
Oklahoma	− .0863 ± .07	22.43	100
Horace Mann	.146 ± .07	17.13	100
Hebrew Orphans	.0047 ± .07	15.64	100
Composite	− .194 ± .07 (1st Method) .156 ± .06 (2nd Method)	22.76 (2nd Method)	100

2. Achievement

	Total r	Mean Difference	No. of Pairs
Oklahoma	.199 ± .09	17.96	50
Horace Mann	.031 ± .10	15.58	50
Composite	− .169 ± .09 (1st Method) .0079 ± .10 (2nd Method)	19.40 (2nd Method)	50

3. Accomplishment:

	Total r	Mean Difference	No. of Pairs
Oklahoma	$-.199 \pm .09$	13.60	50
Horace Mann	$-.149 \pm .09$	14.26	50
Composite	$.022 \pm .10$ (2nd Method)	14.96 (2nd Method)	50

C. Matching Experiments

1. Unrelated Pairs

	Total r	Mean Difference	No. of Pairs
Oklahoma	$-.0093 \pm .07$	19.67	100
Horace Mann	$.075 \pm .07$	15.78	100
Hebrew Orphans	$-.095 \pm .07$	17.11	100

2. The True Sib Pairs

	Total r	Mean Difference	No. of Pairs
Oklahoma	$.564 \pm .05$	12.86	100
Horace Mann	$.279 \pm .06$	14.46	100
Hebrew Orphans	$.270 \pm .06$	11.97	100

The results for the orphan asylum group obtained from the pairing of unrelated children reared together, and related children reared apart were as follows:

A. Unrelated children reared together

	M	σ	N
10–25% of their lives	96.12	11.70	94
50–100% of their lives	93.12	13.50	94

B. Unrelated children reared apart

	M	σ	N
	95.97	13.57	200

C. True sibs reared apart

	r	N	M	σ	N
All pairs	.230 ± .07	78	93.36	11.40	156
One pair, each family ...	.236 ± .10	42	93.45	11.25	156

In the case of true sib pairs of orphans reared apart, correction of the correlation coefficient was made for restricted range. The S.D. of this group was found to be 11.40. For true sib orphan pairs in general, the S.D. obtained was 14.04 points of I.Q.

Using the formula given by Kelley,[12] the following result was obtained:

	Curtailed Range	Uncurtailed Range
True sibs reared apart N = 78	r = .230 ± .07	r = .495 ± .06

The results for the computations of the partial r's are as follows:

A. Partial r—Horace Mann

$r_{12} = .134$
$r_{13} = .868$
$r_{23} = .182$
$r_{14} = .173$
$r_{24} = .866$
$r_{34} = .255$

$r_{12.3} = -.0492$
$r_{14.3} = -.1009$
$r_{24.3} = .862$
$r_{12.34} = .0751 \pm .04$

B. Partial r—Oklahoma

$r_{12} = .163$
$r_{13} = .477$
$r_{23} = -.126$
$r_{14} = -.181$
$r_{24} = .51$
$r_{34} = .0847$

$r_{12.3} = .256$
$r_{14.3} = -.253$
$r_{24.3} = .527$
$r_{12.34} = .474 \pm .02$

C. Partial r—Hebrew Orphans

$r_{12} = .171$
$r_{13} = .743$
$r_{23} = .065$
$r_{14} = .113$
$r_{24} = .727$
$r_{34} = .031$

$r_{12.3} = .184$
$r_{14.3} = .135$
$r_{24.3} = .728$
$r_{12.34} = .127 \pm .04$

[12] Kelley, T., *Statistical Method*, p. 222.

D. Partial r—Composite

$r_{12} = .172$
$r_{13} = .633$
$r_{23} = .0993$
$r_{14} = .104$
$r_{24} = .681$
$r_{34} = .403$

$r_{12 \cdot 3} = .142$
$r_{14 \cdot 3} = .2104$
$r_{24 \cdot 3} = .704$
$r_{12 \cdot 34} = .419 \pm .02$

The results for other constants of the data for which correlations were computed are as follows:

A. True Sibs

1. Intelligence

a. All pairs

	Mean	Standard Deviation	No. of Cases
Oklahoma	88.9	18.35	900
Horace Mann	119.3	15.25	650
Hebrew Orphans	96.89	14.05	506
Composite	100.45	21.27	2056

b. One pair from each family

	Mean	Standard Deviation	No. of Cases
Oklahoma	90.03	18.75	600
Horace Mann	118.80	15.25	482
Hebrew Orphans	96.57	13.8	292
Composite	101.81	21.2	1374

2. Achievement

	Mean	Standard Deviation	No. of Cases
Oklahoma	107.45	17.65	210
Horace Mann	118.32	13.90	166
Composite	112.46	17.05	376

For corresponding I.Q.'s

	Mean	Standard Deviation	No. of Cases
Oklahoma	98.9	17.30	166
Horace Mann	120.10	14.15	210
Composite	108.65	19.15	276

3. Accomplishment

	Mean	Standard Deviation	No. of Cases
Oklahoma	109.75	10.50	210
Horace Mann	99.9	10.95	166
Composite	105.4	12.05	376

4. Matching Experiment

	Mean	Standard Deviation	No. of Cases
Oklahoma	89.50	18.75	200
Horace Mann	119.37	15.15	200
Hebrew Orphans	96.97	14.75	200

CHAPTER VII

INTERPRETATION OF RESULTS, AND CONCLUSIONS

Before making any interpretations or deriving any conclusions from the results of this experiment it is necessary to note certain precautions which must be taken in the interpretations of correlation coefficients, both total and partial.

INTERPRETATION OF CORRELATION COEFFICIENTS

In the first place, correlations may rarely be interpreted or compared at their face values. It may be necessary, for various reasons to be considered here, to discount, attenuate or expand a correlation coefficient before it can be correctly interpreted or used in comparison with another correlation coefficient. Conditions which may vitiate face value interpretations of coefficients may be the small size of the number of cases involved, the range of scores entering into the correlations, the coarseness of score groupings, the randomness of the sampling, the traits being correlated and the method of computation of the correlation coefficient.

In the correlation of intelligence quotients still further considerations, such as the spread of the group in chronological age and the homogeneity of the mental ability of the group, must be taken into account. It is not known whether intelligence quotients are directly comparable at different ages. Certain defects in the tests on which the intelligence quotients are based may tend to vitiate the results.

The interpretations of a partial correlation coefficient may also involve difficulties. The partial correlation coefficient is in the nature of an average correlation between traits. If, for example, total correlations in mental age or intelligence quotients were obtained, at all possible ages, the partial correlation coefficient for mental ages or intelligence quotients with chronological age con-

stant would represent something in the nature of an average of all the correlations.

Furthermore, it must be noted that not all of the information to be obtained from a correlation table is exhibited by a correlation coefficient derived from it.

The interpretation of results, and conclusions will follow the order of the topics investigated:—First, concerning the amount of resemblance; and second, concerning the relative importance of heredity and environment as causes of resemblance.

EVIDENCE CONCERNING THE AMOUNT OF RESEMBLANCE

In all pairings of true sibs positive resemblance in intelligence is found. The same thing is true for school-subject achievement. In several instances, however, this positive resemblance is small and the probable error relatively large, hence in these cases the correlation must be considered negligible, and where the number of cases is small, highly unreliable. Resemblance in intelligence achievement and effort for all pairings of unrelated children cluster around zero, as would be expected when pairings are random.

The results reveal total correlations ranging in size from .27 to .68 for intelligence of true sibs reared together. The variations are due to differences in the number of cases involved, differences in central tendency, variability within each group, and variations in chronological ages of the individuals comprising the different groups. In no case has an unselected population been obtained approximating, for example, a normal distribution of unselected twelve-year-old American school children with a mean at 100 and a standard deviation of 15 points of I.Q. The distribution obtained for the orphan group approaches the normal curve more closely than do those for the other groups. Forming a composite of all the groups increases the range of ability, but also increases the standard deviation of the whole, since the desired proportion of normal or average children is lacking. Forming a composite of the whole also results in a correlation coefficient which is larger than the coefficient of any one of the component parts, as may be expected when groups with different means are joined.

Consequently, no one correlation coefficient for intelligence obtained from the data of this study can be stated as the constant of regression for pairs of true sibs in general. It would, however,

certainly appear to be greater than .3 and less than .7. In general it may be said from the results of this study that association in intelligence between pairs of true siblings is present and of substantial size, but that the correlation is by no means perfect. This means, in the case of siblings, that the chances of siblings duplicating each other, so far as intelligence and achievement as measured by intelligence tests is concerned, are indeed rare. The chances that siblings will resemble each other more than they will unrelated children in the population at large, are certainly on the average great. It cannot be concluded, however, from the results of this study whether one sib will on the average tend to resemble his brother or sister to the extent of one-third, one-half or two-thirds of perfect resemblance.

EVIDENCE CONCERNING THE RELATIVE IMPORTANCE OF HEREDITY AND ENVIRONMENT AS CAUSES OF RESEMBLANCE

Results Derived from the Orphan Asylum Data. The correlation of true sib orphan pairs reared together in the asylum or other previous environment was found to be .322 ± .04 for 253 cases. This must constitute the basis of comparison for the other correlations computed for the orphan data. To the extent, then, to which the orphan true sib correlations can be compared to the true sib correlations for the other groups and to a normal curve for I.Q.'s in general,—to that extent may the various correlations computed for different studies of the orphan group be compared to the results found for true sibs in general.

When true sib orphan pairs are kept apart on an average of four years of life (the period of separation coming at any age from birth to about 12 years) and are then given intelligence tests, the results of which are correlated, there appears to be a positive resemblance of small amount (.230 ± .07 $N = 78$). When corrected for narrow range this correlation resembles (within the probable error) that obtained for true sib orphans reared together.

The resemblance of the sib pairs reared apart, before they were separated, is not known. It might be expected to resemble that for true sib orphans reared together. The indication seems to be, therefore, that differences of environment for a time do not tend to cause true sibs to lose the resemblance they would have shown if reared together. The resemblance found in mental traits must

be innate. The evidence, however, is slight, and the correlations on which the conclusions are based, not highly reliable. There are trends in the direction outlined, but final conclusion in the matter cannot rest on the basis of this result alone.

Unrelated children reared in the same environment (that of an orphan home) 10 to 25 per cent of their lives show, when paired at random and correlated, a correlation of $-.103 \pm .10$ for 47 pairs. This amount of resemblance may be considered negligible. Unrelated children reared together in the same environment 50 to 100 per cent of their lives, resemble each other to the extent of $-.169 \pm .10$ for 47 pairs. This correlation is also negligible. The size of the correlation in this case, however, has no bearing upon the relative effects of heredity and environment in causing resemblance, since random pairings of children of the same parents in a family of infinite size would also be zero. The standard deviations, however, may be used to estimate the influence of the two factors. An investigation of the standard deviations of unrelated children reared together and unrelated children reared apart, reveals only slight variations. In other words, raising a group of children together for from 50 to 100 per cent of their lives does not tend to make them resemble each other any more closely than if they had been kept apart. In an infinitely large family of true sibs of the orphan group the resemblance would be closer.[1]

For this part of the study the small number of cases precludes the finality of any conclusions. These may be chance results. The results lead one to suspect, however, that such an amount of common environment as the children have had does not appear to make unrelated children resemble each other any more closely in intelligence as measured by tests than unrelated children in varying environments.

Educational Test Results. Further evidence of a different kind, bearing upon the same problem, is gained from the educational or achievement test results. It has been pointed out by other writers that if environment is the cause of resemblance in mental traits, then we should expect to find greater resemblances in siblings in traits more subject to training than in traits less

[1] Galton shows that Variability of Family $= \sqrt{1 - r^2} \times$ Variability of the Genera Population. See Pearson, K., "Notes on History of Correlation." *Biometrika*, Vol. 13, 1920-21, p. 32.

subject to training. The results for correlations based on school subject achievement give us measures which may be said to be more subject to school training than measures of intellectual capacity, such as the intelligence quotients of the present study.

Comparing the amounts of resemblance in intelligence and in school achievement for the two groups measured, the Oklahoma group shows for true siblings, in both measures, similar amounts of resemblance (I.Q.'s: $r = .647 \pm 04$, $N = 105$. E.Q.'s: $r = .579 \pm .04$, $N = 105$). The Horace Mann group shows slightly less similarity between the two groups (I.Q.'s: $r = .312 \pm .07$, $N = 83$. E.Q.'s: $r = .418 \pm .06$, $N = 83$). This may be caused by fluctuation due to sampling, or, though small, it may be a real difference. The unreliability of the difference between the r for the I.Q.'s and the r for the E.Q.'s in the Horace Mann group was computed by the formula given by Thorndike:[2]

$$\left(\sigma_{\text{true-obt. diff. A-B}}\right) = \sqrt{\left(\sigma_{\text{true-obt. A}}\right)^2 + \left(\sigma_{\text{true-obt. B}}\right)^2}$$

In this case, $\sigma_{\text{(true-obt. diff. A-B)}}$ amounted to .134. McCall's[3] formula for computing what is called the experimental coefficient, was used in order to determine whether the actual difference found between the two r's was a significant difference.

$$\text{Experimental Coefficient} = \frac{\text{Difference}}{2.78 \text{ S.D. Difference}}$$

The coefficient obtained was .28. This may be interpreted to mean that the chances are about 3.5 to one that the difference found (.106) is a real difference. In both groups the amounts of resemblance of true sibs in intelligence and school achievement may be said to be similar. True sibs on the average, therefore, do not appear to be more similar in ability much subject to the environmental influence of training than in traits little subject to training. The resemblance found would appear to be innate rather than environmentally conditioned.

[2] Thorndike, E. L., *Mental and Social Measurements*, p. 193.
[3] McCall, W. A., *How to Measure in Education.*

CHAPTER VIII

SUMMARY

1. In this research there has been involved the investigation of three phases of the problem concerning the resemblance of siblings in intelligence and in achievement:

   a. To determine whether or not siblings show positive resemblance in intelligence and in achievement.

   b. To determine the amount of this resemblance.

   c. To discover whether the factor of heredity or of environment is the more important factor in the explanation of the cause of resemblance in siblings in intelligence and achievement.

2. A summary of previous studies of the same and related problems revealed a concensus of evidence that positive resemblance of varying amount is found, and that to heredity rather than to environment is to be attributed the cause of this resemblance.

3. Data for the study came from three sources: Oklahoma school children, Horace Mann School children, and Hebrew orphans.

4. The tests used in measuring intelligence and achievement respectively, were revisions of the Binet Simon Scale and the Stanford Achievement Tests.

5. The methods of measuring resemblance employed were correlation, total and partial, and the method of mean differences.

6. The results obtained show positive resemblance for all pairings of true sibs. School children tend to show about the same resemblance in achievement in school subjects that they do in intelligence.

True siblings reared apart for part of their lives still resemble each other about as much as true sibling pairs reared together. Unrelated children reared together for part of their lives resemble each other in intelligence no more closely than unrelated children chosen from the population at random.

7. The conclusions reached were that sibling resemblance is present, of substantial size in general, though far from perfect. A constant of regression for the intelligence of siblings in general cannot be derived from these data.

Heredity rather than environment appears to be the cause of the resemblance found.

APPENDIX

CASE STUDIES

Studies in greater or less detail were made of a few Oklahoma families. These cases are cited in order to give actual pictures of typical families. The studies do not affect the conclusions drawn from the objective data obtained. They simply illustrate what may happen in the best and worst of families. Differences as well as resemblances between sibs, it must be remembered, can be explained by the laws of heredity.

Family A. This family is representative of the best stock in the town. The members are said to be descended from the famous A-family, one of the best in the South. The father at the time of the study was a bookkeeper, conscientious, exacting, and precise; probably of high normal or superior intelligence, scrupulous in church attendance, an adherent to form and ritual. The mother impresses all with her refinement and modesty. She is devoted to her family and keenly interested in all that concerns them. She was formerly a school teacher, and has recently been president of a parent-teacher organization. She undoubtedly has superior intelligence.

There are two children, girls, *(a)* and *(b)*, aged six and ten at the time they were tested. Their I.Q.'s are 143 and 135, but the mere statement of the I.Q.'s gives no idea of their stability and general superiority. The older child is precise, exact, dependable in all she does. She always heads the class, no matter what class. She is never known to have an "off-day." Her manner, vocabulary, and common sense make her appear several years older than her actual chronological age. The younger child shows many of the same characteristics. The first grade teacher remarked that the child helped her teach school. The child's ambition at six was to be a school teacher. Her capacity for remembering and retelling stories is remarkable. She relates her stories with excellent English and delightful detail. Her superiority in many other lines is also evident, with the consequence that her school progress, as in the case of the older child, has been rapid.

Family B. This is a family of four boys of varying ability. Their I.Q.'s and the ages at which they were tested are *(a)* I.Q. 135, age 10; *(b)* I.Q. 100, age 9; *(c)* I.Q. 119, age 7; *(d)* I.Q. 108, age 6. The mental tests show all the children to be normal or superior in intelligence. The differences, however, between the children are evident to teachers and supervisors who do not know the actual intelligence quotients. These boys have a fortunate environment. They have a cultured, intelligent mother who

believes in freedom and activity for boys. The father was an oil operator, successful in his dealings, and the family is well-to-do. A more healthful and happy family of boys would be hard to find. Their environment has brought out the best in each. They make varying rates of progress in school, about in proportion to their I.Q.'s. The mother is aware of the intellectual differences, and sensibly makes allowance for them. These children have a boy cousin, an only child, who has an I.Q. above 140.

Family C. This is a family of three brothers and one sister, in some respects similar to Family B. The I.Q.'s and ages are *(a)* I.Q. 113, age 11; *(b)* I.Q. 112, age 11; *(c)* I.Q. 118, age 13; *(d)* I.Q. 101, age 6. These children have a narrower range of I.Q.'s than family B, but here again differences in ability are more or less apparent. This family, however, is in decided contrast to family B in respect to environment. Family C has little wealth or culture. The parents are average people with little background. The father is a policeman. The home environment is at best mediocre and not conducive to a realization of the best in the children.

Family D. This family journeyed from the lowlands of a neighboring state by wagon and camped upon the outskirts of the town. They are not gypsies, but transients just the same. They stayed several weeks, during which time the school nurse clothed them, the truant officer sent them to school, and the psychologist examined them. Their previous education had been scant, and culture of any sort was lacking. The father's occupation was not determined. The I.Q.'s and ages are: *(a)* boy I.Q. 63, age 14; *(b)* girl I.Q. 59, age 15; *(c)* girl I.Q. 96, age 10; *(d)* boy I.Q. 76, age 12. One child has normal intelligence; the others are dull and of low grade. Differences in chronological age may make some difference in the I.Q.'s obtained. Even making allowance for this fact, it seems evident that this is a case of poor stock which makes its own poor environment.

Family E. This is a family of numerous progeny. Before the marriage of the parents, they had each had children by previous marriages. The final combination resulted in a three-ply family, his children, her children, and their children. Only "his" and "her" children have had mental tests. "Their" children had not entered school at the time the older children were tested. The I.Q.'s and ages of the mother's children are *(a)* boy I.Q. 57, age 16; *(b)* girl I.Q. 73, age 13; *(c)* girl I.Q. 66, age 14; *(d)* boy I.Q. 74, age 10. The father's children are *(a)* girl I.Q. 58, age 14; *(b)* girl I Q. 81, age 11.

All of the children are below normal in intelligence. There are others who have not been tested. All are shiftless, lazy, incompetent. They reside in a three-room shack, having only the barest of necessities. The writer had occasion to call shortly after the arrival of the youngest member of the family,—a pitifully weak infant bearing many marks of inferiority. The father is always out of a job and in constant need of support from charity. During the cotton season, the family migrate to the fields and make a feeble effort to earn a living. All of the children are in special classes in the public schools when they can be legally compelled to attend. The whole picture is one of degradation and inferiority.

Family F. This family is a study in contrasts. The older child, a girl aged 10 with an I.Q. of 96, makes normal progress in school, and though a little timid, is to all appearances perfectly normal. The younger child, a boy aged 9 with an I.Q. of 54, is psychopathic and feeble-minded, in need of institutional care. He is impossible to manage in an ordinary school room. He remembers nothing from day to day, nor in fact from hour to hour. He chatters incessantly and so incoherently that it is impossible to find any sensible associations in the flow of words. He is equally restless and uncontrolled in all his physical behavior. One parent shows some signs of instability. The girl at 10 years of age was in the fifth grade doing normal work; the boy at nine in the first grade could accomplish little. A thorough investigation of the family history might throw some light upon the causes of the differences.

Family G. This family has two children, girls, one *(a)* 10 years of age with an I.Q. of 81, and *(b)* 13 years of age with an I.Q. of 27. The younger child at the time of the test was progressing slowly in the second grade. The older child, an imbecile, had of course never been to school. Her mental age fits her well, although she is large physically. She is babyish in all reactions, and afraid of everything and everybody. She clings to her mother in all emergencies and strange situations, in true baby fashion.

Family H. The children of this family are also contrasts, showing seemingly more differences than similarities. The older, a boy of 13 with an I.Q. of 95 is slow and plodding, with a great antipathy for schools and teachers. If one waits long enough, a desirable and satisfactory response may be forthcoming, as the I.Q. would indicate. Few people, however, have the time to give the boy a chance, and the result is lack of adjustment all round. He is a misfit in the giddy rush about him. He has superb physique, and is reported to be training as a prize-fighter. Possibly mental and physical speed have been latent, and will appear when the necessity arises. The other child, a girl 8 years of age with an I.Q. of 116, does superior school work and has made rapid progress in the grades. Her work is of good quality, accurately and quickly done. She is the delight of her teachers, dainty, neat, and charming. Her chief delight is in arithmetic, in which she excels. Teachers who have taught both children are baffled by the contrast.

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